An Open Platform for Digitizing Real World through Sentient Artefact Model

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Talk Outline

- Motivation
- Scenario
- Sentient Artefact
  - Design Principle
  - Sentient Artefact Development Framework
  - Unification
- Sentient Artefact based location System
- Sentient Artefact based Ad-hoc Micro World Model
- Wrap Up
- Other works

Motivation

- Two primary research assumptions in Pervasive Computing are wrong
  - A Global World Model (Middleware!!) for hosting **ANY** applications
    - Simply Impossible; Looking at History and projecting future with current technology...
    - World Model is not only **LOCATION MODEL**
  - Lets stop saying, we are heading towards.....SMART, Context-Aware world, 16 years have already passed looking for that world.
    - Do you want to build your house again?
    - Cost factor!!

Motivation

- Perhaps one feasible way to approach so-called smart environment is utilizing our existing environment, i.e. existing everyday artefacts
  - Indoor Only
- We still do not properly understand or limit the affordability of everyday artefacts.
  - How everyday artefacts can be modified to inject functionality that we expect to have in pervasive environment?
  - Once augmented everyday artefacts can monitor and acquire real world information and location dependent ad-hoc federation among these artefacts can provide collection of data models that can be used by applications in that location as long as the access semantics are clarified and unified.

Everyday Life

Sentient Artefact

- Sentient Artefact
  - Sentient artefacts are everyday objects augmented with various kinds of sensors and actuators that suit their appearance and primary functionalities.
  - This augmentation allows these artefacts to provide value added functionalities (so-called context like: state-of-use, environment attributes etc.) beyond their primary roles.

Sentient Artefact

- Design Principles
  - Complying with primary roles.
  - No dedicated infrastructure.
  - Natural and implicit interaction.
    - We do not want to give target users a100 page manual to use a chair.
    - Domain requires self explanatory interaction mechanism.
  - Reusability
  - Communication Capable

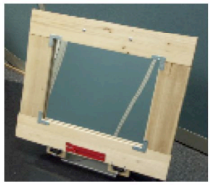
Illustrations

Sentient table provides ambient display service

Sentient Chair provides state of use information like sitting/not sitting

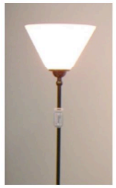
Sentient Tray can identify objects it carries

Sensor augment PDA provides variety of physiological and environmental sensor data



AwareMirror provides ambient display service

Sentient Toothbrush provides state of use information and identifies user



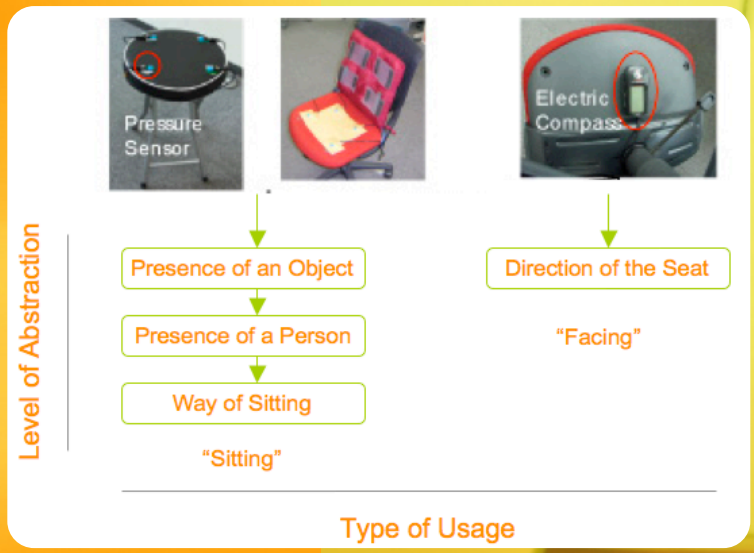
Sentient lamp provides ambient light level with light service

Sentient Clock can identify Alarm setup timing

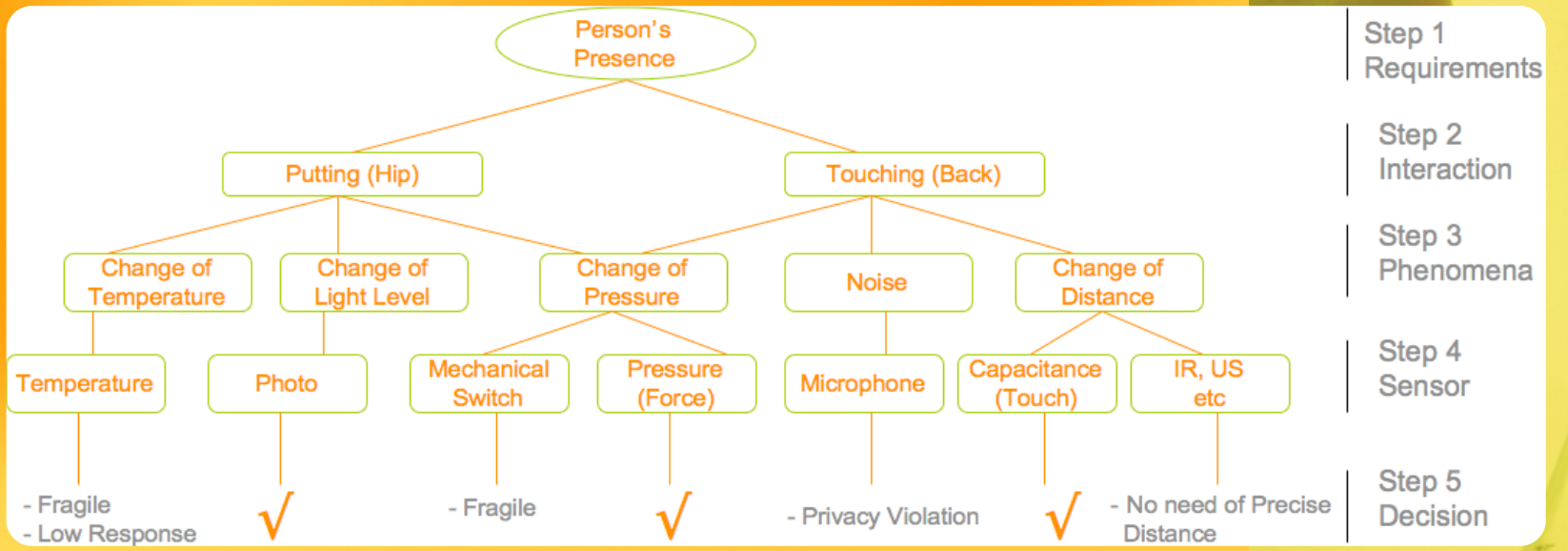
Sentient Door can identify opening/closing event

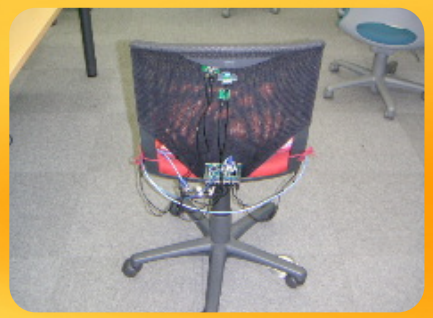
Development Steps

- 5-Steps Development Framework based on our experiences
  - Step 1: Specify the Required Functionality
  - Step 2 : Analyze the Artefact's Usage and Interaction
  - Step 3: Clarify Observable Phenomena
  - Step 4: List the Candidates of Sensors
  - Step 5: Select the Appropriate Sets of Sensor



Example

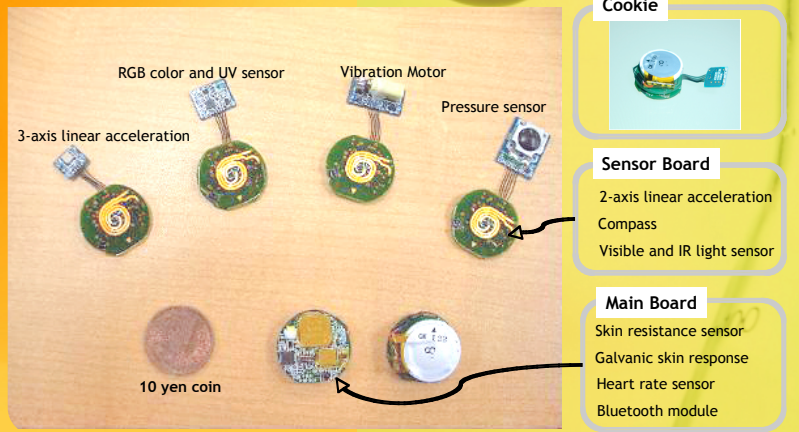

Person's Presence
Putting (Hip)
Touching (Back)
Change of Temperature
Change of Light Level
Change of Pressure
Noise
Change of Distance
Temperature
Photo
Mechanical Switch
Pressure (Force)
Microphone
Capacitance (Touch)
IR, US etc
- Fragile
- Low Response
√
- Fragile
√
- Privacy Violation
√
- No need of Precise Distance
Step 1 Requirements
Step 2 Interaction
Step 3 Phenomena
Step 4 Sensor
Step 5 Decision



Our Augmentation Platform

Gumstix running Linux 2.6

Phidget Sensors



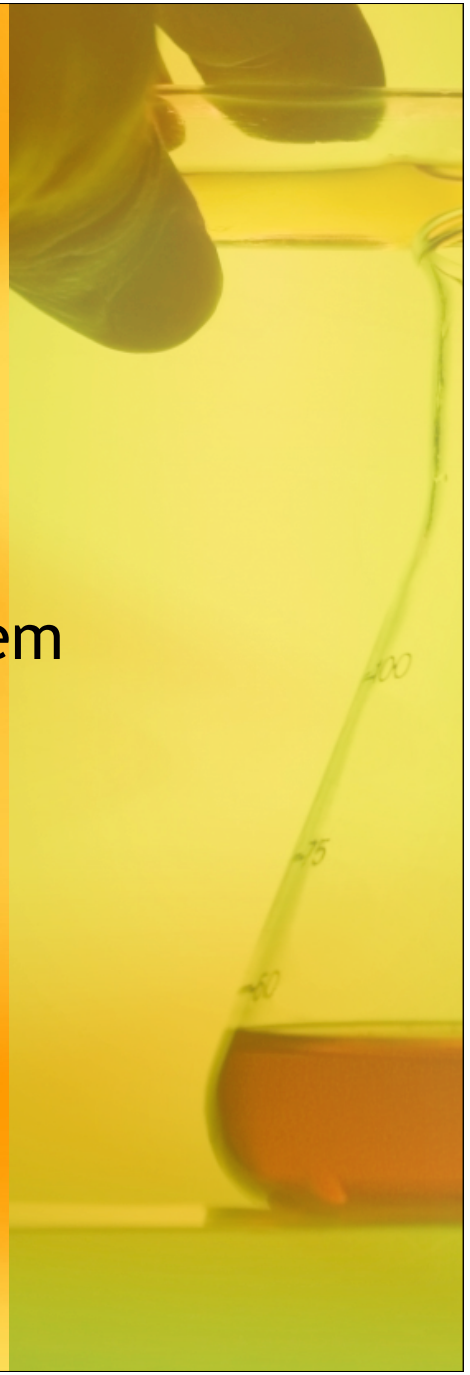
Cookie Wireless Sensor Node

Sentient Artefact

- Two Issues
- How to determine the sentient artefacts participation in context aware applications in a generic way?
  - We must not develop application or scenario dependent sentient artefacts, rather we have to come up with generalized artefacts that can be used in various scenarios and are independent from the applications.
- How sentient artefacts location can be acquired?
  - It is expensive and to impractical to use dedicated sensor infrastructure for location sensing in domestic environment. We confronted the fact that we need some alternative approaches that can provide the location information in an inexpensive and natural way.

Resolution

- A Profile based approach
- Sentient Artefact based Location System



Artefact Profile

Ambient Display

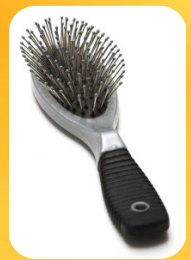
Application A

Proximity Detector

Application B

One Artefact With Multiple Roles

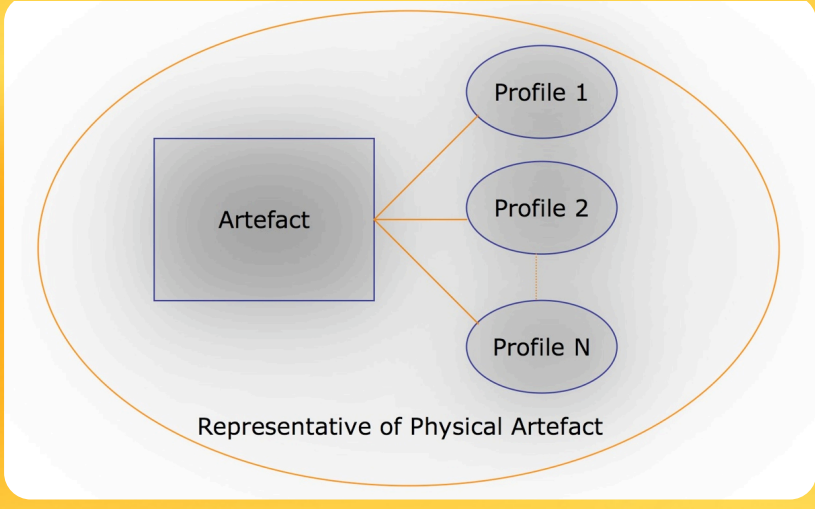
Artefact Profile



Multiple Artefacts with Similar Roles

Profile

- A Profile simple indicates the value added role that an artefact can play considering its affordability.
  - Supports loose coupling among artefacts' functionalities.
  - Realistic and appropriate



Input Profile	Output Profile
- Time (Explicit or Symbolic like Evening etc.) - Location (Symbolic like meeting room or Geometric with longitude, latitude) - Position (Front, Back, Right, Left, In front etc) - Voice - Tag Reader - Authentication - Proximity and Distance - Information (Weather, News, Schedule etc) - State of Use - Emotion - Activity - Environment Attribute (Temperature, Light Level, Humidity etc) - Physical State (Height, Weight, Color, Shape, Size, Temperature, Face Up/Down, Held, etc)	- Sound/Noise - Display - Vibration - Lighting - Movement - Controlling (On, Off, Up, Down, Open, Close etc) - Leveling (Darker, Stronger, Weaker, Lighter etc) - Sending Message (Email/SMS) - GUI Event (Display) etc.

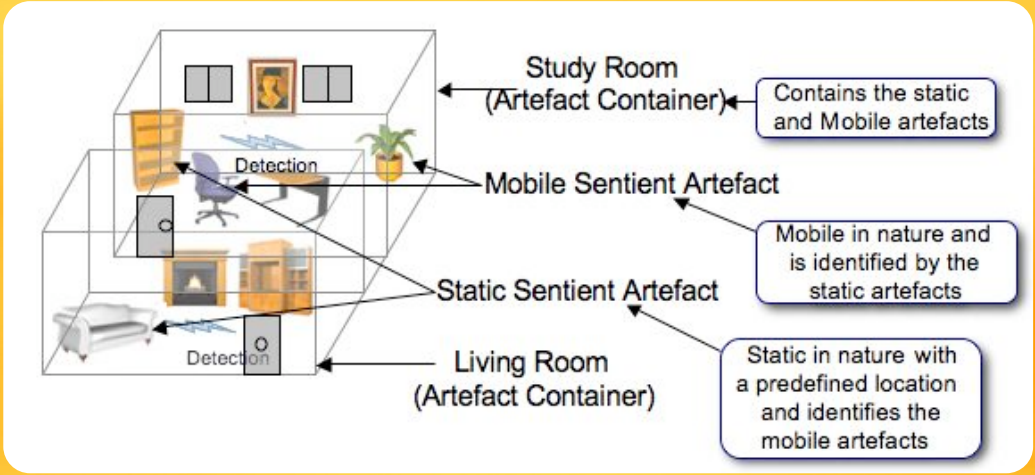
Location Identifier Profile

- Many daily life artefacts are immobile in nature and we rarely move them once placed.
- We can augment these artefacts with location identifier profile to identify their peer mobile artefacts



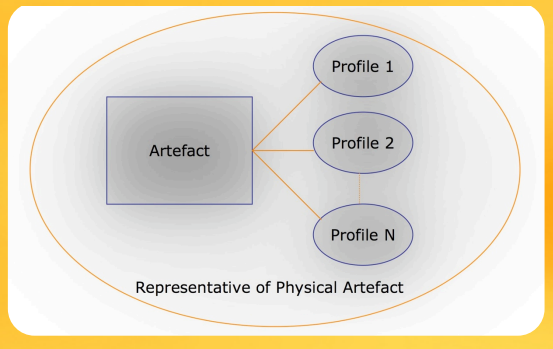
Spreha Location Model

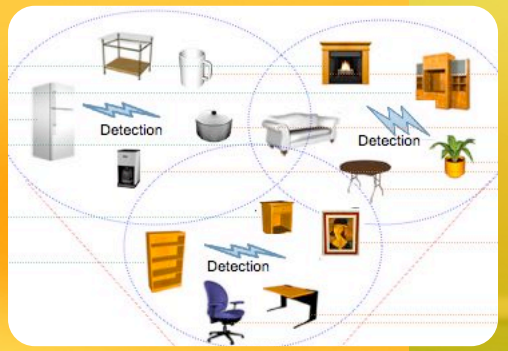
- Implication of Immobile Observation
- Bluetooth Based Implementation
  - Precision Room Level (Ask me if you want to see the evaluation)



Sentient Artefact

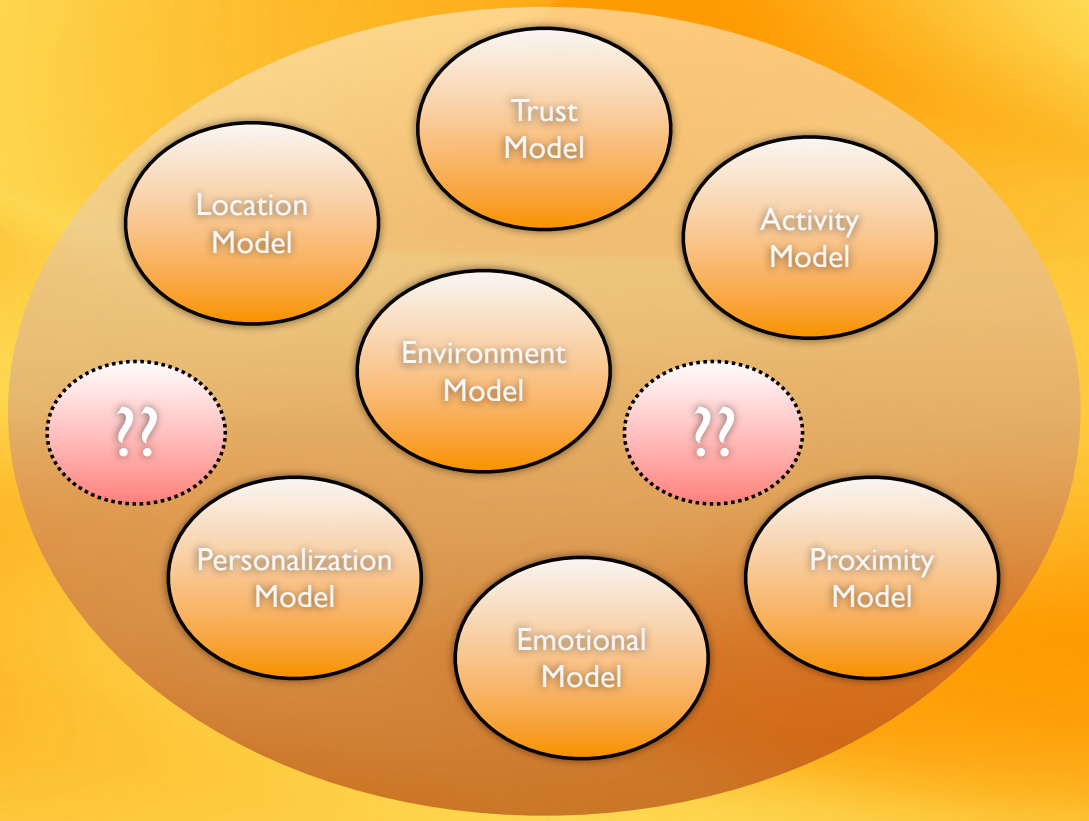
- Sentient Artefact
  - Each Artefact implements one or more generic service profiles. These profiles specifies the generic capabilities of an artefact including context sensing
  - Each Artefact is self contained and can communicate with others to create a federation





Back to Basics

- World Model



Back to Basics

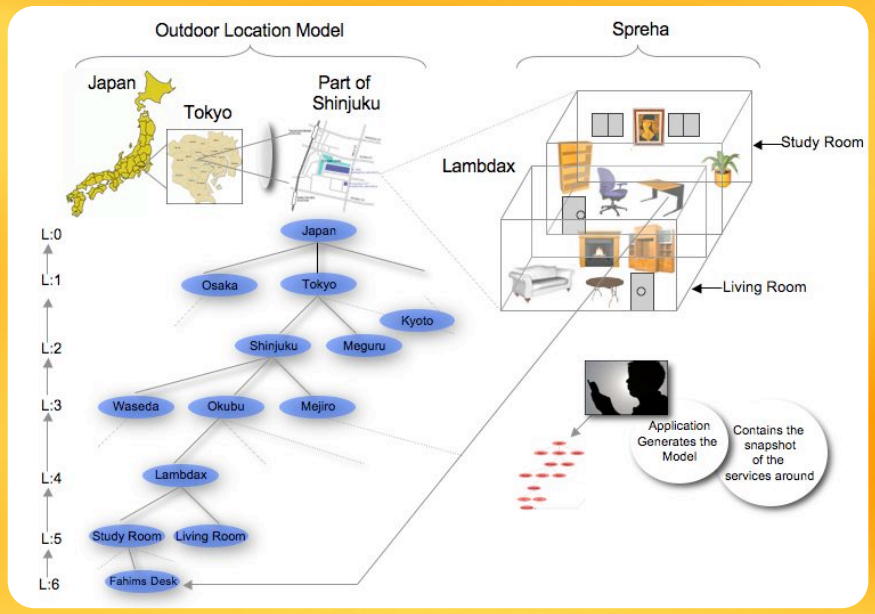
- Observations
  - A model is only needed when there are service consumers at the service location. Service itself might not need the model always.
  - Most of the services are local, meaning runs under specific constrains
- Sentient Artefact in conjunction with Users personal Device can provide **a few** of the models service request basis (WiP)
  - Spontaneous and Ad-hoc federation of artefacts to provide models based on consumers spatial location
  - Micro Scale partial world model

Approach (WiP)

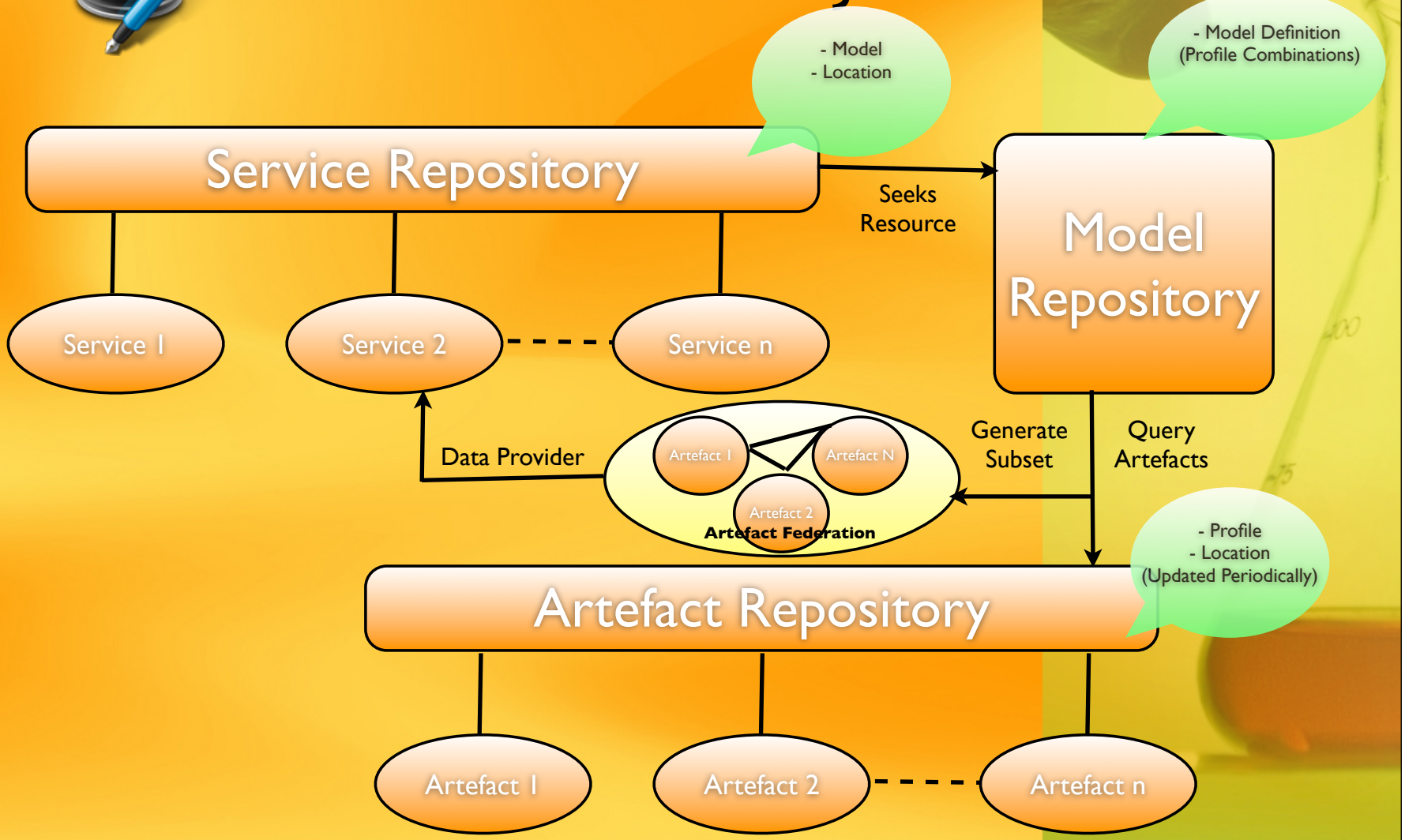
- Sentient Artefact as *Primary Actor*
  - Self Contained, Profile Specific, Independent.
- Artefact Federation as *Primary Action*
  - Service Oriented, Temporal, Spatial and Spontaneous.
  - Service requests initiates the adhoc-federation
- Service-Independent Data Platform as *Primary Relationship*

Approach

- Model Generation
  - Ad-hoc and Spontaneous Initiated by the Applications specifying the requirement. Users spatial location as the key.
  - Location mapping is done through Spreha Concept



Platform :Bird's Eye View



Approach

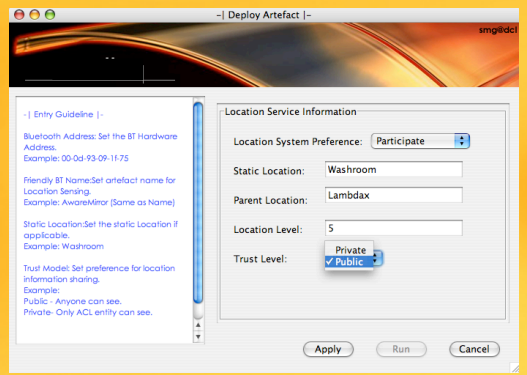
- Model
  - Model is a higher abstract than context in our assumptions.
    - Model can be user centric (Personalization, Personal Collection Artefacts)
    - Model can be service centric
    - Model can location centric
    - May be more !!!
  - Specifies Required Model
    - APIs are provided to abstractly request a model specifying location and models

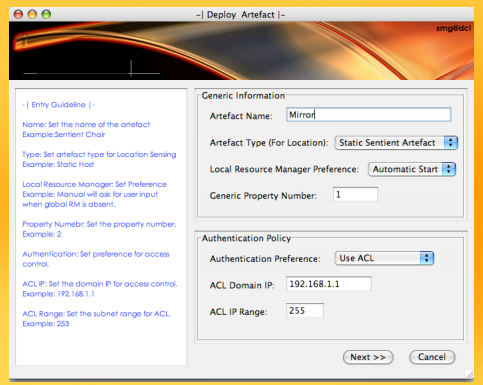
Approach

- Artefact Federation
  - Federation is logical grouping artefacts that gives us a specific logical model
  - There might be multiple federation existing in the same location for different services with same artefacts.

Approach

- Artefact Repository
  - Define and implement Profiles
  - APIs are provided to abstract heterogeneous connectivity (BT, WiFi, RS232 etc.)
  - Deployment Tools are provided. Developers only need to implement the profiles.



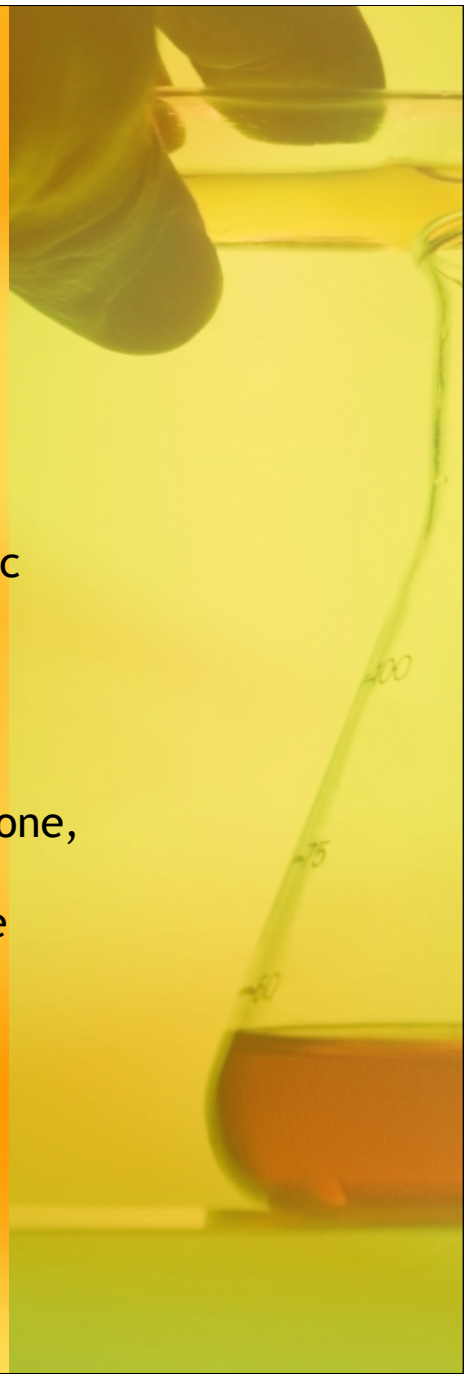


Approach

- Service Developers
  - Define and implement Service
  - Specifies Required Model
    - APIs are provided to abstractly request a model specifying location and models
    - Returned Model hides the artefacts federation and provides data required for the service

Current Status

- Definition of Model
  - Still investigating how we can provide a generic semantics!
- Model Access Semantics
  - Conceptually once the artefact federation is done, we have a data repository specific to service, however currently we are assuming the service developers are are aware of the model access semantics for that specific service!
  - This approach needs refinement



Implications

- Implications
  - Service-Centric Artefact Federation
  - Less Overhead, Better Data management
  - No Physical Data Model, all @ dynamic time.
  - Profile based Generalization and Ad-hoc federation together provides a platform accessible from any applications, existing and future ones.
  - An Optimistic Approach to solve many middleware issues and increasing inter-operability.
  - A Business Model for Future Sentient Artefact Vendors

Wrap Up

- Sentient Artefact
  - Design and Development
  - Implications of Sentient Artefact
  - An optimistic approach to model real world at micro scale.
    - Work In Progress